



Economics of LED vs HID Lighting Systems

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The Question?

- Compared to HID based product solutions, do LED product solutions have the potential to more positively impact the environment and the economy?

Maximum Green / Maximum Greed

Possibilities

- ◆ Lower associated energy, waste, maintenance and disposal costs
 - Lower total encompassed energy cost to produce the LED product alternative
 - Lower Product Life Cycle Costs?
 - Lower total encompassed energy cost to maintain and dispose of the LED product alternative
 - Lower operating energy over life
 - Lower First Cost / First Installed Cost?
 - Greater recyclability
 - Higher recyclable content
 - Lower net cost and energy required to recycle
 - Higher US Based Manufacturing Content

Product Lifecycle Material Processing and Handling

HID

- Raw Material Processing (Harvesting, Mining, etc.)
- Fabrication
 - ◆ Stamping
 - ◆ Casting
 - ◆ Other Molding
 - ◆ Extruding
 - ◆ Finishing
 - ◆ Assembly
- Installation
- Scheduled Maintenance (re-lamping / lamp disposal)
- Salvaging and Recycling
- Transportation
- Etc.

LED

- Raw Material Processing (Harvesting, Mining, etc.)
- Fabrication
 - ◆ Stamping
 - ◆ Casting
 - ◆ Other Molding
 - ◆ Extruding
 - ◆ Finishing
 - ◆ Circuit Board Assembly
 - ◆ Assembly
- Installation
- Scheduled Maintenance (no re-lamping)
- Salvaging and Recycling
- Transportation
- Etc.

Typical Manufactured Components HID

- Fixture Housing

- ◆ Aluminum

- Die Cast
 - Extruded
 - Fabricated

- Optical Assembly

- ◆ Aluminum Reflector
 - ◆ Glass Refractor / Lens
 - ◆ Plastic Refractor / Lens

- Control Gear

- ◆ Magnetic Ballast / Electrolytic Capacitor / Electronic Ignitor

- Lamp



Typical Manufactured Components LED

- Fixture Housing
 - ◆ Aluminum
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 - Fabricated
- Optical Assembly
 - ◆ Aluminum Reflector
 - ◆ Glass Refractor / Lens
 - ◆ Plastic Refractor / Lens
- Control Gear
 - ◆ Electronic Driver
- Packaged LED / Circuit Board Assembly



Possible LED Benefits over HID

Current and Future

- Lower Manufacturing Process Energy Consumption for Comparable Lighting Performance
 - ◆ Cleaner (i.e. Greener) Manufacturing Processes?
- Lower Transportation Resources Required
 - ◆ Comparably Smaller / Lighter Weight Products
 - ◆ Comparably Higher % USA Based Transportation
 - ◆ Lower Service Requirements (Re-lamping)
- Lower Carbon Foot Print?
 - ◆ If so, how do we quantify it?

Lower Operating Carbon Footprint?

- Higher Target Efficacy
 - ◆ Comparably Better Application Level Performance With Less Energy Consumed
 - Lower power density

Optimizing LED Target Efficacy

- Thermal Management
- Optical Control

Thermal Management

■ Goal

- ◆ Maximize Light Extraction From LED Package
- ◆ Minimize Lumen Depreciation
 - Maximize Lumen Maintenance

Optical Control

Bare LED Package Illustration



Optical Control

Illustration of Altered
Distribution
(Secondary Optic Added)





Cub Foods



LED Scalability Benefit

- Potential for Greater Granularity in Delivered Luminous Flux at the Luminaire Level
 - ◆ <100 lumen increments Possible for luminaires incorporating High Power 1 watt LEDs
 - Application “Fine Tuning” potential

Economic Challenges Compared to HID

Cost Scaling

■ HID Products

◆ Lower cost per delivered lumens for higher power products

■ Example

- 70W Metal Halide Product = \$X
- 150W Metal Halide Product \approx \$1.2X

Cost Scaling

- LED Products

- ◆ **Slightly** Lower cost per delivered lumens for higher power products

- Example

- 30 LED Product = \$X
- 60 LED Product \approx \$1.7X

Possible Barriers to Adoption

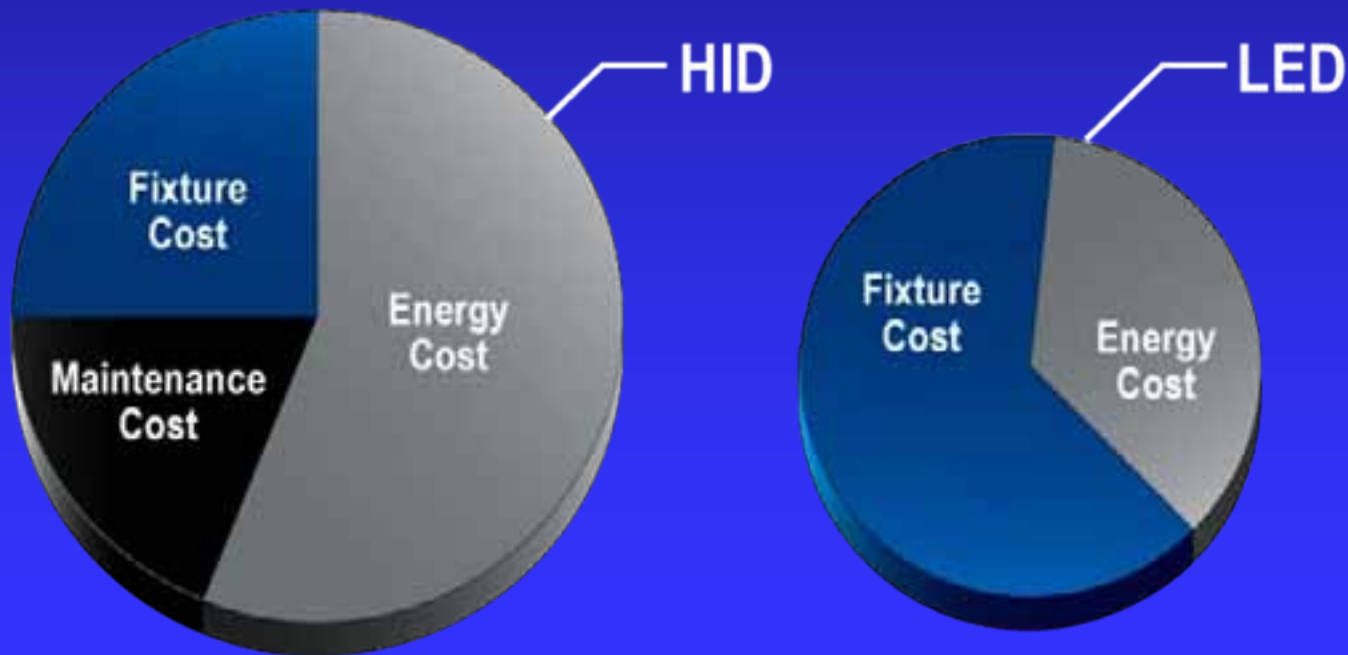
- High First Cost
- Long Payback Period
 - ◆ Product Warrantee Shortfall
- Uncertainty in Predicted Long Term Performance
 - ◆ Lumen Maintenance
 - ◆ Color Stability
- Insufficient / Incomplete Product Performance and Reporting Standards
- Lack of Application Level Experience and Recommended Practices

Mercury?

- ~40 million MH lamps in US
(1-100 mg of Mercury per Lamp)
 - ◆ 70 W MH (~4 mg of Mercury)
 - ◆ 400 W MH (~60 mg of Mercury)
- Coal Burning Power Plants

Value Analysis

Total Cost of Ownership Illustration





Thank You

Eric Haugaard

Opportunities and Challenges

Product Lifecycle Environmental Effects

LED vs Others

■ Outdoor Street and Area Lighting Products

◆ HID

- Metal Halide
- High Pressure Sodium
- High Pressure Mercury

◆ LED

Economic Optimizing



Drive Current / LED Count Balance

Arbitrary Example

Drive Current (mA)	350	525
# of LED's	50	40
Total Delivered Lumens At 50,000 Hours (\approx 12 years)	4085	3818
Consumption (watts)	66	84
Efficacy (LPW)	61.89	45.45
Product Cost	\$X+150	\$X